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PROCEDURE FOR MAKING QUASI-SYNCHRONOUS DECISIONS FOR CHANGING CHANNELS

The invention relates to a procedure for making quasi-synchronous channel-changing decisions in accordance with the preamble of Claim 1.

During data transmissions via radio channels it is possible, particularly in the short-wave range, for disruptions to occur that interfere with or completely prevent the reception or the correct evaluation of the data transmitted. For this reason it is customary to conduct data transmissions on the basis of a communication protocol according to the so-called ARQ (Automatic Repeat Request) procedure. To this effect, the sender sends blocks of data, and the recipient then confirms the receipt of any correct (interpretable) data by returning an acknowledgment telegram to the sender. In his acknowledgment telegram (also called "block acknowledgment," or simply "acknowledgment"), the recipient communicates to the sender which frames in the most recently received block are being received in the proper quality and which data did not have the correct quality, thus requesting the sender to repeat the data that so far were not received in the correct form. The data blocks are customarily divided into a prefix and a plurality of data frames, and the data are evaluated and acknowledged, or requested to be resent, frame by frame. If the transmitted data, in addition to the actual message, also contain redundancy information, errors in transmission can be recognized and corrected where necessary. A data frame is considered to have been correctly received if its message content can be interpreted without error, taking the redundancy information into account. Decision-making devices that can do this are known.

However, interferences on a channel that is in use can so severely impair data transmission that it can be advisable, if the interference continues for a protracted period, to change the radio channel so as to allow for the current data transmission to be completed entirely and within a reasonable period. Such a channel change must be as synchronous as possible at both the sender's and the recipient's end. A simple solution is the sending of a channel change telegram by which one of the participants who considers it necessary from his own vantage point to change the radio channel, requests the other participant to switch to a radio channel indicated in the telegram or to another channel that was previously agreed upon. Of course, since the disruptions experienced on the channel can also affect the aforementioned channel change

telegrams, a channel change request that is transmitted in this way may possibly also fail to be transmitted in the correct quality and result in no mutual channel switch being triggered.

The object of the present invention therefore is to provide a procedure of the type indicated in the preamble of Claim 1 that ensures that a quasi-synchronous channel change decision is made at both the sender's and the recipient's end.

The invention is described in Claim 1. The dependent claims contain preferred embodiments and refinements of the invention.

In the procedure described in the invention, the sender and the recipient independently update and assess the transmission quality of the channel, but do so on the basis of equivalent criteria and arrive at the decision to change channels quasi-synchronously by way of an evaluation function. The process is independent of the characteristics (such as degree and time behavior) of an interference on a transmission channel currently in use, and most particularly does not depend on the transmission of special channel change telegrams.

The effort sums are a measure of the cumulative number of repeated frames, or frames to be repeated, and thus of the effort that was necessary, up to the current evaluation moment, to correctly transmit, for the first time, the number of frames indicated by the correct sums.

In the following, the invention is explained in detail by means of examples. They are based on the premise that the connection on a channel has been completed and the data transmission is carried out according to the above-referenced ARQ procedure.

In order to transmit a complete message, the sender transmits data blocks, each consisting of a prefix and a number of frames. For all blocks, the number of frames within a block is equal to or smaller than a maximum value M. A frame comprises a plurality of characters of the message to be transmitted, as well as redundancy for the characters of this frame. By co-assessing the redundancy, the recipient can detect transmission errors with near certainty, decide whether it is possible to correct the recognized errors, and correct them where appropriate. A frame whose message content is received free of error or as a minimum can be fully corrected is deemed to have been correctly received. By way of example, a block prefix might contain information such as a block number, the number of frames in the block, as well as identifiers for the frames in the block which were already contained in the preceding block, but which due to their faulty

reception are now being repeated in accordance with the most recently transmitted acknowledgment telegram.

Upon receipt of a block, the recipient transmits an acknowledgment telegram—also called a block acknowledgment—, in which he communicates which frames of the most recently received block have so far been received with errors or which were correctly received. The sender interprets the block acknowledgment as a confirmation of correctly received frames which thus do not need to be retransmitted, as well as a request to have the incorrect frames repeated in the next data block.

If the sender receives a block acknowledgment for the last block sent, he transmits a new block. The new block then contains the frames that were reordered in the block acknowledgment, as well as new frames if there is space available. The new block is identified by having its block number increased by the number of one relative to the most recent block that was sent.

If the sender fails to receive the block acknowledgment for the most recently transmitted block within a certain timeframe, he repeats the most recently sent block and identifies it as a block repeat by retaining the block number of the block.

The transmission can basically be disrupted in such a way that any block or any block acknowledgment is partially or completely destroyed and can be interpreted by the recipient only incompletely or not at all. If there is an accumulation of such disruptions or transmissions are no longer possible on the current transmitting channel, switching to another transmitting channel is advisable. Such a channel change should take place as simultaneously as possible at both the sender's and the recipient's end.

To this effect, correct sums KS[1] and KE, and effort sums AS and AE, are formed on both the sender's and the recipient's side. The sums are formed by evaluating the information transmitted in the blocks and/or block acknowledgments and, where necessary, by taking the processes into account which resulted in an expected block or an expected block acknowledgment not being received. At the beginning of a transmission and after every change of the transmission channel, the correct sums and effort sums are standardized such that the sender and the recipient have the same start values. The recipient's correct sum KE indicates how many data frames the recipient received correctly for the first time, while the sender's correct sum KS indicates the number of

[1] *"S" = "sender"; E = "recipient" – Translator's note.*

frames whose correct reception is established based on acknowledgment telegrams for the sender. A difference between the two correct sums KE and KS can occur when the recipient receives some or all frames in a block correctly and accordingly sends the sender an acknowledgment telegram which either fails to arrive at the sender's or is faulty upon arrival. In this event, only the correct sum KE of the recipient is increased (depending on the number of correctly received frames in the block), but not the correct sum KS of the sender. If no acknowledgment telegram is received or the sender receives a faulty acknowledgment telegram in return, the sender repeats the preceding block using the same block number. This repeat is recognized as such at the recipient's end and treated as an indication that the last acknowledgment telegram either did not arrive at the sender's or arrived with errors. A frame that is correctly received in the repeat block only causes the recipient's correct sum KE to be increased if that frame was not properly received in the preceding block. In this way, the difference between the correct sums KE and KS at the recipient's or the sender's end can, at a maximum, equal the maximum number M of frames within a block.

The effort sums AS and AE are a measure of the cumulative number of repeated frames or frames which must be repeated, and thus of the effort that was necessary, up to the current evaluation moment, to correctly transmit, for the first time, the number of frames indicated by the correct sums.

The sender calculates the effort sum AS based on the block acknowledgments received and the processes that lead to a block being repeated. If the sender receives an expected block acknowledgment, he increases AS by the number of frames that were reordered in the block acknowledgment. If the sender is unable to receive an expected block acknowledgment or it arrives incomplete, he increases AS by the maximum number M of the frames in a block.

The recipient calculates his effort sum AE on the basis of the frames that were reordered in block acknowledgments, processes where some blocks were received multiple times, and processes during which an expected block failed to be received. If the recipient receives a new block (i.e., no block bearing that block number has as yet been received), or he receives a block for the first time following a channel change, he increases AE by the number of frames he needs to have resent from that block. If the recipient is unable to receive an expected block, he increases AE by the maximum number M of frames in a block. If the recipient receives a block repeatedly (i.e., the block number of the block just received has not changed relative to the

previously received block), and if this block is not the first block received after a channel switch, he increases AE by the maximum number M of the frames in a block and by the number of frames of this block that must be reordered, minus the number of frames that were reordered on receiving the preceding block.

Devices such as digital counters, accumulators and similar equipment are suited to calculate the correct sums and effort sums.

To assess the quality of the current transmission channel, the sender and the recipient use the same evaluation function. The evaluation function is defined by its determination, for each permissible number of data frames, of the amount of effort that is permissible for the correct transmission of these frames on the current transmission channel without needing to change the channel. The evaluation function exists as an allocation of a threshold value T for the current effort sums AE and AS to the current correct sums KE and KS.

If the current value of AE and AS exceeds the threshold value belonging to the actual value of KE and KS, which threshold value is circumscribed by the evaluation function, a change of channel is deemed to be mutually agreed.

The evaluation function is applied by the sender and the recipient whenever the transmission of a block and its associated block acknowledgment can be regarded as completed in accordance with the above-described transmission protocol (this also includes all possible types of failures), and the channel quality parameters have been updated.

An example of an evaluation function might be a straight line that has a positive ordinate intercept and whose gradient is greater than one. If an ordinate intercept has a value greater or equal to the maximum number of frames in a block, a channel change is prevented from being initiated in the event of serious transmission errors that occur immediately after the transmission of the first block. The positive gradient causes a channel change to occur only if the transmission is severely disrupted over a prolonged period of time after many blocks have been transmitted error-free. The choice of the straight line parameters in this example is particularly suited for so-called “bursts” that are a very frequent occurrence in ionospheric disruptions.

Other evaluation functions can also be applied. It can be particularly useful during extended transmission periods to use a monotonically rising evaluation function whose gradient diminishes as the number of frames increases.

By utilizing a counting method previously agreed to by the sender and the recipient, the procedure described herein ensures that the current counter readings of the channel quality parameters differ at most by the maximum number of frames in a block. Since the sender and recipient use the same decision-making criteria, this means that both of them arrive almost simultaneously, i.e. quasi-synchronously, at the decision to change channels.

In particular, the procedure described here allows the current transmission channel to be changed even if the reception at the sender's or the recipient's end or at both ends is completely disrupted.

It is possible to further enhance the procedure described by combining it with the transmission of channel change request telegrams.